I. Binary Compounds of Metals with Fixed Charges

A. Given Formula, Write the Name

A binary compound is one made of two different elements. There can be one of each element such as in NaCl or KF. There can also be several of each element such as Na_2O or $AlBr_3$. Please remember that all elements involved in this lesson have **ONLY ONE** charge. That includes **BOTH** the cation **AND** the anion involved in the formula.

Points to remember about naming a compound from its formula

1. The order for names in a binary compound is first the cation, then the anion.
2. Use the name of cation with a fixed oxidation state directly from the periodic table.
3. The name of the anion will be made from the root of the element's name plus the suffix "-ide."

Example 1: Write the name of the following formula: **Na_2S**
Step #1 - Look at first element and name it. Result of this step = sodium.
Step #2 - Look at second element. Use root of its full name (which is sulf-) plus the ending "-ide." Result of this step = sulfide.
These two steps give the full name of Na_2S. Notice that the presence of the subscript is ignored. There are other types of binary compounds where you must pay attention to the subscript. Those compounds involve cations with variable charges.
The name of this compound is sodium sulfide.

Three possible mistakes to be aware of:
1) Often students forget to use the suffix "-ide." For example, BaS is named "barium sulfide." An unaware student might want to name it "barium sulfur."
2) Make sure that the second name is the root plus "-ide." An unaware student might want to name BaS as "barium sulfuride." NaBr is not named sodium bromineide, the correct answer is sodium bromide.
3) There is a set of binary compounds that are named using Roman numerals. Students often confuse the two sets of rules. For example, a student might want to name Na_2S as sodium (I) sulfide. While it is never wrong to use the Roman numerals, your teacher will probably want you to only use Roman numerals on certain cations.
Here are examples of common roots:

F:	fluor-	N:	nitr-
Cl:	chlor-	P:	phosph-
Br:	brom-	As:	arsen-
I:	iod-	Se:	selen:
O:	ox-	C:	carb-
S:	sulf-		

Chemical Nomenclature: **WS#1** Completed:_______________

Write the correct name for:

1) MgS	
2) KBr	
3) Ba_3N_2	
4) Al_2O_3	
5) NaI	
6) SrF_2	
7) Li_2S	
8) Al_2S_3	
9) CaO	
10) AlP	
11) K_2S	
12) LiBr	
13) Sr_3P_2	
14) $BaCl_2$	
15) NaBr	
16) MgF_2	
17) Na_2O	
18) SrS	
19) K_2O	
20) AlN	
21) Cs_2O	
22) RbI	
23) MgO	
24) $CaBr_2$	
25) LiI	

B. Given Name, Write the Formula

There can be one of each element such as in sodium bromide or potassium iodide. There can also be several of each element such as lithium oxide or aluminum bromide.
Please remember that all elements involved in this lesson have **ONLY ONE** charge. That includes **BOTH** the metal **AND** the nonmetal involved in the formula.

Points to remember about writing the formula from the name

1. The order in a formula is first the cation, then the anion.
2. You must know the charges associated with each cation and anion.
3. The sum of the positive charge and the sum of the negative charges MUST add up to zero.
4. You **MAY NOT** adjust the charges of the cations or anions to get a total charge of zero.
5. You **MAY** adjust the subscripts to get a total charge of zero.

Page xx in the appendix entitled "Charge-Crossing" technique shows a way to write these formulas correctly.
The Least-Common-Multiple method shows still a different slant on how to figure out a formula. I hope you're not too confused by the multiplicity of presentations. They are actually presenting the same thing different ways.

Example 1: Write the formula from the following name: **barium iodide**
Step #1 - Write down the symbol and charge of the first word. Result = Ba^{2+}
Step #2 - Write down the symbol and charge of the second word. Result = I^{-}
Step #3 - Use the minimum number of cations and anions needed to make the sum of all charges in the formula equal zero. In this case, only one Ba^{2+} is required, but two I^{-} are required.
Why? Answer - Two negative one charges are required because there is one postive two charge. Only in this way can the total charge of the formula be zero.
The resulting formula is BaI_2.

Example 2: Write the name of the following formula: **magnesium oxide**
Step #1 - Write down the symbol and charge of the first word. Result = Mg^{2+}
Step #2 - Write down the symbol and charge of the second word. Result = O^{2-}
Step #3 - Use the minimum number of cations and anions needed to make the sum of all charges in the formula equal zero. In this case, one Mg^{2+} is required, as well as one O^{2-}.
Why? Answer - One positive two charge is counterbalanced by one negative two charge. This gives a zero total charge for the formula.
The resulting formula is MgO.

Write the correct formula for: Completed:_______________

1) magnesium oxide	
2) lithium bromide	
3) calcium nitride	
4) aluminum sulfide	
5) potassium iodide	
6) strontium chloride	
7) sodium sulfide	
8) barium bromide	
9) magnesium sulfide	
10) aluminum nitride	
11) cesium sulfide	
12) potassium chloride	
13) strontium phosphide	
14) barium iodide	
15) sodium fluoride	
16) calcium bromide	
17) lithium chloride	
18) strontium sulfide	
19) boron fluoride	
21) aluminum oxide	
22) calcium iodide	
23) calcium fluoride	
24) magnesium iodide	
25) lithium chloride	

II. Binary Compounds of Cations with Variable Charges

A. The Stock System: Given Name, Write the Formula

This lesson shows you how to write the formula of a binary compound from the word name when a cation of variable charge is involved. The four formulas above are all examples of this type.

The cations involved in this lesson have AT LEAST TWO charges. The anions involved have only one charge.

The type of naming you will learn about is called the Stock system or Stock's system. It was designed by Alfred Stock (1876-1946), a German chemist and first published in 1919 This suggestion has not been followed, but the Stock system remains in use world-wide.

Example #1 - Write the formula for: **iron (III) sulfide**

Step #1 - the symbol of the cation is Fe.

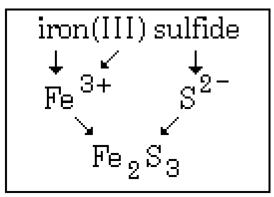
Step #2 - the charge on the cation is a positive three. Remember, that comes from the Roman numeral.

Step #3 - Sulfide (the anion) means S^{2-}.

Step #4 - since a formula must have zero total charge, you write the formula Fe_2S_3.

if you're not sure about how the subscripts in iron(III) sulfide came to be; look at the Least-common-multiple reference.

This graphic summarizes example #3:



Example #2 - Write the formula for: **tin (IV) phosphide**

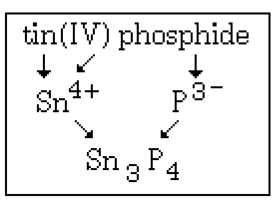
First symbol is Sn from the name tin.

The Roman numeral IV gives +4 as tin's charge.

Phosphide give P^{3-}.

This compound's formula is Sn_3P_4.

This graphic summarizes example #4:



Write the correct formula for: Completed:_______________

1) iron(II) chloride	
2) copper(I) sulfide	
3) lead(IV) iodide	
4) tin(II) fluoride	
5) mercury(I) bromide	
6) tin(II) oxide	
7) chromium(III) oxide	
8) gold(I) iodide	
9) manganese(II) nitride	
10) cobalt(III) phosphide	
11) iron(III) chloride	
12) copper(II) sulfide	
13) lead(II) bromide	
14) tin(IV) iodide	
15) mercury(II) fluoride	
16) tin(IV) oxide	
17) manganese(III) chloride	
18) chromium(II) nitride	
19) gold(III) oxide	
20) cobalt(II) phosphide	
21) tin(II) sulfide	
22) mercury(I) sulfide	
23) gold(III) bromide	
24) manganese(II) oxide	
25) chromium(II) chloride	

B. The Stock System: Given Formula, Write the Name

There can be one of each element such as in CuCl or FeO. There can also be several of each element such as Fe_2O_3 or $SnBr_4$.
This lesson shows you how to name binary compounds from the formula when a cation of variable charge is involved. The four formulas above are all examples of this type.
The cations involved in this lesson have AT LEAST TWO charges. The anions involved have only one charge.
The type of naming you will learn about is called the Stock system or Stock's system. It was designed by Alfred Stock (1876-1946), a German chemist. This suggestion has not been followed, but the Stock system remains in use worldwide.

Example #1: Write the name for: **$FeCl_2$**
Step #1 - the first part of the name is the unchanged name of the first element in the formula. In this example, it would be iron.
Step #2 - the result from step one **WILL** be followed by a Roman numeral. Here is how to determine its value:

1. multiply the charge of the anion (the Cl) by its subscript. Ignore the fact that it is negative. In this example it is one times two equals two.
2. divide this result by the subscript of the cation (the Fe). This is the value of the Roman numeral to use. In this example, it is two divided by one equals two.
3. The value of the Roman number equals the positive charge on the cation in this formula.

Since the result of step #2 is 2, we then use iron (II) for the name. Notice that there is no space between the name and the parenthesis.
Step #3 - the anion is named in the usual manner of stem plus "ide."
The correct name of the example is iron (II) chloride.

Example #2: name this compound: **$CuCl_2$**
In this example, I've explained it differently. Compare it to the one above. Example #4 is also explained this way.

- The first part of the name comes from the first element symbol: copper.
- The Roman numeral is II, because 2 chlorides equal -2, so the Cu must be +2. (It must be +2 so that the total charge equals zero.
- The second part of the name comes from the root of the second symbol plus 'ide,' therefore chlor + ide = chloride.

This compound is named copper (II) chloride.

Write the correct name using the Stock system for: Completed:_______________

1) CuS	
2) $PbBr_4$	
3) Pb_3N_2	
4) Fe_2O_3	
5) FeI_2	
6) Sn_3P_4	
7) Cu_2S	
8) $SnCl_2$	
9) BaO	
10) MgF_2	
11) $CuCl_2$	
12) CuBr	
13) PbO	
14) Fe_2S_3	
15) $PbCl_2$	
16) SnO	
17) Cu_2O	
18) PbO_2	
19) FeO	
20) SnO_2	
21) CaO	
22) Hg_2I_2	
23) $AuCl_3$	
24) MnO	
25) $CrCl_3$	

III. Binary Compounds of Cations with Variable Charges

A. Common Name System: Given Name, Write the Formula

Here is what the IUPAC currently says about this naming system: "The following systems are in use but not recommended: The system of indicating valence by means of the suffixes -ous and -ic added to the root of the name of the cation may be retained for elements exhibiting not more than two valences."

In everything that follows, remember this overall guiding principle: the total positive charge MUST equal the total negative charge.

Here is a small list of common names of elements YOU must know.

Element	Root	
iron	"ferr-"	
lead	"plumb-"	
copper	"cupr-"	
tin	"stann-"	

Example #1: cuprous chloride
Step #1 - cuprous is the name of a very specific cation. It is the copper ion with a +1 charge.
Step #2 - chloride is the name of a specific anion. It is Cl^{-}.
Step #3 - remembering that the total charge of the formula must be zero, you write the formula CuCl.

Example #2: ferrous oxide
Ferrous means Fe^{+2}
Oxide means O^{-2}
Following the usual rules, you write FeO for the formula.

Example #3: ferric sulfide
Ferric gives Fe^{+3}
Sulfide is S^{-2}
The formula is Fe_2S_3
Keep the charge crossing in mind as you think about how this formula was made. Specifically, examine the aluminum oxide example.

Write the correct formula for: Completed:_______________

1) cupric phosphide	
2) cupric sulfide	
3) plumbous chloride	
4) ferric bromide	
5) ferrous oxide	
6) cuprous nitride	
7) stannous fluoride	
8) ferrous iodide	
9) plumbic oxide	
10) plumbous bromide	
11) cuprous fluoride	
12) stannic sulfide	
13) ferric sulfide	
14) plumbous oxide	
15) ferric chloride	
16) stannic oxide	
17) cuprous sulfide	
18) ferrous chloride	
19) cobaltic iodide	
20) plumbic phosphide	
21) ferrous nitride	
22) stannous bromide	
23) plumbous sulfide	
24) cupric oxide	
25) cuprous chloride	

B. Common Name System: Given Formula, Write the Name

This lesson shows you how to name binary compounds (using the common naming system) from the formula when a cation of variable charge is involved. The four formulas above are all examples of this type. Important point to remember: the cations involved in this lesson have variable charges. The anions involved have only one charge.
Specifically, the use of "-ous" and "-ic" will be studied.

Example #1: FeO
Step #1 - the first part of the name is the root of the first element in the formula plus a suffix. For iron the root to use is "ferr-". The suffix will be either "-ous" or "-ic."
Here is how to determine the suffix.

1. multiply the charge of the anion (the O) by its subscript. Ignore the fact that it is negative.
2. divide the result by the subscript of the cation (the Fe). This gives the positive charge on the cation.
3. the lower of the two values for a given cation is assigned the ending "-ous" and the higher uses the ending "-ic."

The result from (1) and (2) just above is two. (As you memorize the various charges, you will also internalize the above three steps.)
That last part merits a repeat: the lower of the two values will use the "-ous" ending and the higher will use "-ic." I can see you saying to yourself "How in the world do I know which one is the lower and which one is the higher?" Answer - you will know from your studies which one is lower and which is higher.
For example, iron takes on a +2 value and a +3 value. As you begin to learn these values, the question of lower and higher becomes much easier. Trust me!
Step #2 - the anion is named in the usual manner of stem plus "ide."
The answer to this example is ferrous oxide.

Example #2: Fe_2O_3
When you multiply the anion's charge (negative two) by its subscript (three) and drop the sign, you get six for an answer.
Then you divide the six by two (the iron's subscript) and you get three. This means the charge on each iron is positive three.
Since this is the higher of the two charges, the term "ferric" is used.
The answer to this example is ferric oxide.

Example #3: $CuCl_2$
The first part of the name comes from the first element's root: cupr-.
Two chlorides equal -2, so the Cu must be +2. "-ic" is used because +2 is the HIGHER of the two charges copper is known to have.
The second part of the name comes from the root of the second symbol plus 'ide,' therefore chlor + ide = chloride.
This compound is named cupric chloride.

Write the correct common name for: Completed:_______________

1) CuS	
2) $PbBr_4$	
3) Pb_3N_2	
4) Fe_2S_3	
5) FeI_2	
6) CuF_2	
7) Cu_2S	
8) $SnCl_2$	
9) PbO	
10) Sn_3P_4	
11) Fe_2S_3	
12) $PbCl_2$	
13) Sn_3N_4	
14) FeS	
15) $FeBr_3$	
16) SnF_2	
17) FeS	
18) SnI_4	
19) Cu_2O	
20) Pb_3P_4	
21) CuO	
22) SnO_2	
23) PbO_2	
24) Fe_2O_3	
25) CuI	

IV. Binary Compounds of Two Nonmetals

A. The Greek System: Given Formula, Write the Name

This system of naming does not really have an officially accepted name, but is often called the Greek system (or method). It involves use of Greek prefixes when naming binary compounds of two nonmetals. t

A binary compound is one made of two different elements. There can be one of each element such as in CO or NO. There can also be several of each element such as BF_3 or OCl_2.

This lesson shows you how to name binary compounds from the formula when two nonmetals are involved. The four formulas above are all examples of this type. Important point to remember: **NO metals are involved**. That means one of the nonmetals will be acting in the positive role while the other is negative.

In fact, you do not even need to know the charges, since the formula comes right from the element names and their prefixes. Be aware that heavy use of Greek number prefixes is used in this lesson. Here are the first ten:

Number	Prefix	Number	Prefix
one	mono-	six	hexa-
two	di-	seven	hepta-
three	tri-	eight	octa-
four	tetra-	nine	nona-
five	penta-	ten	deca-

Example #1 - write the name for $\mathbf{NO_2}$.

Step #1 - part of the first name is the unchanged name of the first element in the formula. In the examples above, it would be nitrogen.

If the subscript of the first element is 2 or more, you add a prefix to the name. In the first example above, you would write dinitrogen. If the subscript is one as in the second example above, you <u>DO NOT</u> use a prefix. You simply write the name, in this example it would be nitrogen.

Step #2 - the anion is named in the usual manner of stem plus "ide." In addition, a prefix is added. In the first example, the prefix is "mono-" since there is one oxygen. In the second example, use "di-" because of two oxygens.

The correct names of the two examples are dinitrogen monoxide and nitrogen dioxide.

Note that "monoxide" is written rather than "monooxide." It sounds better when spoken out loud.

Example #2- write the name for $\mathbf{N_2O_5}$.

Step #1 - the first element is nitrogen and there are two. This part of the name will be "dinitrogen."

Step #2 - the second element is oxygen, so "oxide" is used. Since there are five, the prefix "penta" is used.

The name of this compound is "dinitrogen pentaoxide." Many write is as "dinitrogen pentoxide."

Write the correct name for: Completed:_______________

1) As_4O_{10}	
2) BrO_3	
3) BN	
4) N_2O_3	
5) NI_3	
6) SF_6	
7) XeF_4	
8) PCl_3	
9) CO	
10) PCl_5	
11) P_2O_5	
12) S_2Cl_2	
13) ICl_2	
14) SO_2	
15) P_4O_{10}	
16) UF_6	
17) OF_2	
18) ClO_2	
19) SiO_2	
20) BF_3	
21) N_2S_5	
22) CO_2	
23) SO_3	
24) XeF_6	
25) KrF_2	

B. The Greek System: Given Name, Write the Formula

Example #1 - write the name for **carbon monoxide**.
Step #1 - the first name will tell you the first element in the formula. In the first example above, it would be N and in the second, C.
If there is a prefix on the name, this gives the subscript on the element. In the first example above, the "di-" tells you there are two nitrogens. Absence of a prefix, as in the second example, says there is only one of that element involved.
Step #2 - the anion name tells you the element; oxide means oxygen. Once again, the prefix will tell you how many of the elements are involved. "Tri-" means three and "mono-" means one.
The correct formulas of the two examples are N_2O_3 and CO.
Note that "monoxide' is written rather than "oxide" when there is one atom of the second element involved. Note also that when one element of the first atom is involved, no "mono-" is used. Monocarbon monoxide is just as wrong as carbon oxide.

Example #2 - write the formula for **bromine pentafluoride**.
Step #1 - the first symbol is Br and its subscript will be a one, which is understood to be present.
Step #2 - the second element is fluorine, so F is used. The prefix "penta-" indicates a subscript of 5.
The formula of this compound is BrF_5.

Example #4 - write the formula for **diphosphorous pentoxide**.
Step #1 - the first symbol is P and the subscript is 2.
Step #2 - pentoxide says five oxygens are involved.
The formula of this compound is P_2O_5.

Write the correct formula for: Completed:_______________

1) chlorine monoxide	
2) oxygen difluoride	
3) boron phosphide	
4) dinitrogen monoxide	
5) nitrogen trifluoride	
6) sulfur tetrachloride	
7) xenon trioxide	
8) carbon dioxide	
9) diphosphorous pentoxide	
10) phosphorous trichloride	
11) sulfur dioxide	
12) bromine pentafluoride	
13) disulfur dichloride	
14) boron trifluoride	
15) tetraarsenic decoxide	
16) silicon tetrachloride	
17) krypton difluoride	
18) chlorine monoxide	
19) silicon dioxide	
20) boron trichloride	
21) dinitrogen pentasulfide	
22) carbon monoxide	
23) sulfur trioxide	
24) dinitrogen trioxide	
25) dinitrogen monoxide	

V. Compounds Involving a Polyatomic Ion

A. Given Formula, Write the Name

These compounds to follow ARE NOT binary compounds. They contain three or more elements, as opposed to only two in a binary compound.
Consequently, a warning: it is important that you learn to recognize the presence of a polyatomic ion in a formula. Many students have made it their first priority to make a set of flashcards with the name on one side and the ion <u>and its charge</u> on the other. Then, carry them everywhere and <u>use</u> them.
The cations used will be a mix of fixed charges AND variable charges. You must know which are which.

Use of Parenthesis

When more than one polyatomic ion is required, parenthesis are used to enclose the ion with the subscript going outside the parenthesis. For example, the very first formula used is $Fe(NO_3)_2$. This means that two NO_3^- are involved in the compound. Without the parenthesis, the formula would be $FeNO_{32}$, a far cry from the correct formula.
When you say a formula involving parenthesis out loud, you use the word "taken" as in the formula for ammonium sulfide, which is $(NH_4)_2S$. Out loud, you say "N H four taken twice S." OR with the formula for copper(II) chlorate, which is $Cu(ClO_3)_2$. You say " Cu Cl O three taken twice."

Example #1 - write the name for **$Fe(NO_3)_2$**
Step #1 - decide if the cation is one showing variable charge. If so, a Roman numeral will be needed. In this case, iron <u>does</u> show variable charge.
If a variable charge cation is involved, you must determine the Roman numeral involved. You do this by computing the total charge contributed by the polyatomic ion. In this case, NO_3^- has a minus one charge and there are two of them, making a total of minus 2.
Therefore, the iron must be a positive two, in order to keep the total charge of the formula at zero.
Step #2 - determine the name of the polyatomic ion. Nitrate is the name of NO_3^-.
The correct name is iron(II) nitrate. The common name would be ferrous nitrate.

Example #2 - write the name for **NaOH**
Step #1 - the cation, Na^+, does not show a variable charge, so no Roman numeral is needed. The name is sodium.
Step#2 - OH^- is recognized as the hydroxide ion.
The name of this compound is sodium hydroxide.

Example #3 - write the name for **$KMnO_4$**
Step #1 - the cation, K^+, does not show a variable charge, so no Roman numeral is needed. The name is potassium.
Step#2 - MnO_4^- is recognized as the permanganate ion.
The name of this compound is potassium permanganate.

Example #4 - write the name for **Cu_2SO_4**
Step #1 - decide if the cation is one showing variable charge. If so, a Roman numeral will be needed. In this case, copper <u>does</u> show variable charge.
If a variable charge cation is involved, you must determine the Roman numeral involved. You do this by computing the total charge contributed by the polyatomic ion. In this case, SO_4^{2-} has a minus two charge and there is only one, making a total of minus 2.
Therefore, the copper must be a positive one. Why? Well, there must be a positive two to go with the negative two in order to make zero. Since the formula shows two copper atoms involved, each must be a plus one charge.
Step #2 - determine the name of the polyatomic ion. Sulfate is the name of SO_4^{2-}.
The correct name is copper(I) sulfate. The common name would be cuprous sulfate.

Example #5 - write the name for **$Ca(ClO_3)_2$**
The first part of the name comes from the first element's name: calcium. You also determine that it is not a cation of variable charge.
The second part of the name comes from the name of the polyatomic ion: chlorate.
This compound is named calcium chlorate.

Example #6 - write the name for **$Fe(OH)_3$**
Iron is an element with two possible oxidation states. The iron is a +3 charge because (1) there are three hydroxides, (2) hydroxide is a minus one charge, (3) this gives a total charge of negative three and (40 there is only one iron, so it must be a +3.
Therefore the first part of the name is iron(III).
The second part of the name is hydroxide, the name of the polyatomic ion.
The name of this compound is iron(III) hydroxide (or ferric hydroxide when using the common method).

Write the correct name for: Completed:_______________

1) $AlPO_4$	
2) KNO_2	
3) $NaHCO_3$	
4) $CaCO_3$	
5) $Mg(OH)_2$	
6) Na_2CrO_4	
7) $Ba(CN)_2$	
8) K_2SO_4	
9) NaH_2PO_4	
10) NH_4NO_3	

These formulas involve the use of a polyatomic ion.

The cations are all of variable oxidation state, so Roman numerals are needed.

11) $Sn(NO_3)_2$	
12) $FePO_4$	
13) Cu_2SO_4	
14) $Ni(C_2H_3O_2)_2$	
15) $HgCO_3$	
16) $Pb(OH)_4$	
17) $Cu_2Cr_2O_7$	
18) $Cu(ClO_3)_2$	
19) $FeSO_4$	
20) $Hg_2(ClO_4)_2$	

These formulas mix the use of the two types of cations.

21) $KClO_3$	
22) $SnSO_4$	
23) $Al(MnO_4)_3$	
24) $Pb(NO_3)_2$	
25) $Mg_3(PO_4)_2$	
26) CuH_2PO_4	
27) $CaHPO_4$	
28) $Fe(HCO_3)_3$	
29) Na_2CO_3	
30) $MgSO_4$	

B. Given Name, Write the Formula

The cations used will be a mix of fixed charges AND variable charges. You must know which are which.

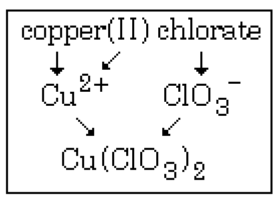
Another warning: you must also know the formula and charge associated with each polyatomic ion' name. For example, NO_3^- is called nitrate and it has a minus one charge. The formula and charge are not inherent in the name.

IMPORTANT: You have to:

1. recognize when a polyatomic is present and
2. know its name.

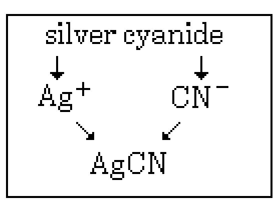
Example #1 - write the formula for **copper (II) chlorate**
Step #1 - the first word tells you the symbol of the cation. In this case it is Cu.
Step #2 - the Roman numeral **WILL** tell you the charge on the cation. In this case it is a positive two.
Step #3 - the polyatomic formula and charge comes from the second name. In this case, chlorate means ClO_3^-.
Step #4 - remembering the rule that a formula must have zero total charge, you write the formula $Cu(ClO_3)_2$.

This graphic summarizes example #1:



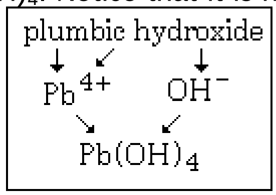
Example #2 - write the formula for **silver cyanide**
Step #1 - the first word tells you the symbol of the cation. In this case it is Ag^+.
Step #2 - silver has a constant charge of +1, it is not a cation with variable charge.
Step #3 - the polyatomic formula and charge comes from the second name. In this case, cyanide means CN^-.
Step #4 - remembering the rule that a formula must have zero total charge, you write the formula AgCN.

This graphic summarizes example #2:

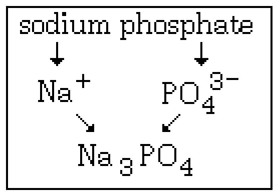


Example #3 - write the formula for **plumbic hydroxide**

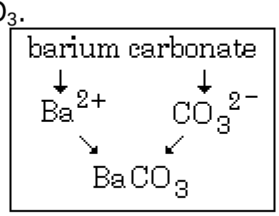
Step #1 - the cation, Pb^{4+}, does show a variable charge. The "-ic" ending means the higher of the two, for this cation that means +4.
Step#2 - hydroxide is recognized as OH^{-}.
The formula of this compound is $Pb(OH)_4$. Notice that it is not $PbOH_4$.

This graphic summarizes example #3: 

Example #4 - write the formula for **sodium phosphate**
Step #1 - the cation, sodium, is Na^{+}, and it does not show a variable charge.
Step#2 - phosphate is PO_4^{3-}.
The formula of this compound is Na_3PO_4. Notice that no parenthesis are required since only one polyatomic is used.

This graphic summarizes example #4: 

Example #5 - write the name for **barium carbonate**
Step #1 - the cation, barium, does not show a variable charge and its symbol is Ba^{2+}.
Step#2 - carbonate is CO_3^{2-}.
The formula of this compound is $BaCO_3$.

This graphic summarizes example #6: 

Write the correct formula for: Completed:_______________

The cations in this first set are all of fixed oxidation state, so no Roman numerals are needed.

1) silver carbonate	
2) potassium phosphate	
3) aluminum hydroxide	
4) sodium hydrogen carbonate	
5) calcium acetate	
6) potassium permanaganate	
7) calcium perchlorate	
8) lithium carbonate	
9) magnesium hydrogen sulfite	
10) sodium hypochlorite	

These formulas involve the use of a polyatomic ion. The cations are all of variable oxidation state, so Roman numerals are needed.

11) tin(IV) chlorite	
12) mercury(II) phosphate	
13) tin(II) carbonate	
14) stannous acetate	
15) lead(II) chromate	
16) copper(I) sulfite	
17) stannous dichromate	
18) iron(III) nitrate	
19) ferric sulfate	
20) ferrous hydroxide	

These formulas mix the use of the two types of cations.

21) potassium perchlorate	
22) lead(II) phosphate	
23) aluminum sulfate	
24) iron(II) bicarbonate	
25) barium iodate	
26) tin(II) hydrogen sulfide	
27) magnesium phosphate	
28) plumbous cyanide	
29) silver phosphate	
30) cobalt(III) nitrite	
and two special additions:	
31) ammonium sulfate	
32) ammonium nitrate	

Mixed Practice Problems

Write correct formulas for the following:

1. calcium chlorate	
2. hydrogen cyanide	
3. ammonium oxide	
4. aluminum bisulfite	
5. cupric hydroxide	
6. aluminum perchlorate	
7. cobalt(III) hydrogen sulfate	
8. copper(I) sulfate	
9. zinc bicarbonate	
10. ferric bicarbonate	
11. lead(II) oxide	
12. chromic hydrogen phosphate	
13. cobaltic chlorate	
14. magnesium nitrate	
15. ammonium hydroxide	

Write correct formulas for the following:

1. chromium(III) oxide	
2. sodium phosphate	
3. phosphorus pentabromide	
4. aluminum oxide	
5. sodium hypochlorite	
6. cobaltous bisulfate	
7. ammonium phosphate	
8. barium carbonate	
9. ferrous chlorite	
10. iron(III) bicarbonate	
11. potassium sulfide	
12. ferrous chromate	
13. tin (IV) bromide	
14. cupric hydroxide	
15. lithium chromate	

16. Ag_2O	
17. P_2O_5	
18. PBr_5	
19. NaH	
20. $KBrO_3$	
21. $Pb(ClO_2)_2$	
22. $AlBr_3$	

23. KOH	
24. IF_7	
25. $Fe(ClO_4)_3$	
26. Cu_2CrO_4	
27. $Ba(NO_3)_2$	
28. K_20	
29. CoO	
30. XeF_2	

VI. Nomenclature of Inorganic Acids

Recognizing an Acid
At this very beginning level, you will recognize an acid by the fact that its formula starts with H, as in these examples:

HCl
HNO_3
H_2SO_4
$HClO_3$
H_3BO_3

As you become more sophisticated in your chemistry, you will realize that there are many acid formulas that do not start with H, but those will almost all be left for another time.
There is one exception to this: the formula CH_3COOH should be recognized as acetic acid. The particular way it is written is common in organic chemistry. An alternate way to write acetic acid is $HC_2H_3O_2$. This is done in the inorganic style that you are currently studying.
One last comment before looking at how to name acids: the formula H_2O should not be considered an acid. It is the formula for water. It is not an acid.

Naming Acids

In order to explain acid naming, the sequence of HCl, HClO, $HClO_2$, $HClO_3$, and $HClO_4$ will be discussed in order.
HCl is a binary acid. All binary acids are named the same way:

1. the prefix "hydro" is used.
2. the root of the anion is used.
3. the suffix "ic" is used.
4. the word "acid" is used as the second word in the name.

The name for HCl is hydrochloric acid. Other binary acids you are responsible for are HF, HBr, HI, and H_2S.

---

1) HClO is an acid involving a polyatomic ion. You MUST recognize the polyatomic ion in the formula. There is no other way to figure out the name. If you don't recognize the polyatomic, then you're sunk without a trace.
The polyatomic ion is ClO^- and its name is hypochlorite. Any time you see the "ite" suffix, you change it to "ous" and add the word acid.
The name of HClO is hypochlorous acid.

---

2) $HClO_2$ has the ClO_2^- polyatomic ion in it. The name of this ion is chlorite.
Since the "ite" suffix is used, it gets changed to "ous."
The name of $HClO_2$ is chlorous acid.

---

3) $HClO_3$ has the ClO_3^- polyatomic ion and its name is chlorate. Any time you know the "ate" ending is used on the polyatomic, you use "ic" when you write the corresponding acid formula. The name of $HClO_3$ is chloric acid.

---

4) $HClO_4$ has the ClO_4^- polyatomic ion and its name is perchlorate.
Since the "ate" suffix is used, it gets changed to "ic."
The name of $HClO_4$ is perchloric acid.

IMPORTANT: You have to:

3. recognize when a polyatomic is present and
4. know its name.

Only then can you know to change the "ite" suffix to "ous" and the "ate" suffix to "ic" when it is an acid.

Common Acid and Anion Names

Acids are compounds containing an ionizable proton (H^+). The polyatomic anions derived from acids are named by dropping the *-ic* (or *-ous*) suffix from the acid name and adding the *-ate* (or *-ite*) suffix, respectively. For example, the sodium salt of nitric acid is sodium nitrate ($NaNO_3$). If you know the acid formula you will *always* get the correct anion formula and its charge, since the charge is equal to the number of ionizable hydrogen atoms in the acid, and is always negative. For example, for sulfuric acid (H_2SO_4), the anion is sulfate (SO_4^{-2}) with a -2 charge.

Acids that do *not* contain oxygen (e.g., HCl, H_2S, HF) are named by adding the *hydro-* prefix to the root name of the element, followed by the *-ic* suffix. HCl is *hydro*chlor*ic* acid, H_2S is *hydro*sulfur*ic* acid, and HF is *hydro*fluor*ic* acid (*italics* added for emphasis). Anions of these acids, which contain a single element (not polyatomic), are named as a regular non-metal anion (i.e., Cl^- is chloride, S^{2-} is sulfide, and F^- is fluoride).

Acid	**Name**	**Anion**	**Name**		**Acid**	**Name**	**Anion**	**Name**
H_2SO_4	sulfuric	SO_4^{2-}	sulfate		HCl	hydrochloric	Cl^-	chloride
HNO_3	nitric	NO_3^-	nitrate		HBr	hydrobromic	Br^-	bromide
H_3PO_4	phosphoric	PO_4^{3-}	phosphate		$HClO_3$	chloric	ClO_3^-	chlorate
$HC_2H_3O_2$	acetic	$C_2H_3O_2^-$	acetate		$HClO_2$	chlorous	ClO_2^-	chlorite
H_2SO_3	sulfurous	SO_3^{2-}	sulfite		$HBrO_3$	bromic	BrO_3^-	bromate
HNO_2	nitrous	NO_2^-	nitrite		HBrO	hypobromous	BrO^-	hypobromite

Write the correct name for: Completed:_______________

1) H_2SO_4	
2) H_2SO_3	
3) HNO_3	
4) HNO_2	
5) H_3PO_4	
6) H_3PO_3	
7) H_2CO_3	
8) $HC_2H_3O_2$	
9) $HClO_4$	
10) $HClO_3$	
11) $HClO_2$	
12) HClO	
13) HCl	
14) HBr	
15) HF	

Appendix:

Greek Number Prefixes

Here are the first ten:

Number	Prefix
one	mono-
two	di-
three	tri-
four	tetra-
five	penta-
six	hexa-
seven	hepta-
eight	octa-
nine	nona-
ten	deca-

Charge Crossing Technique

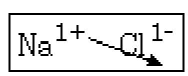
The rules to follow are:

- the total positive charges must equal the total negative charges.
- you cannot change the charges given to you.
- adjust the subscripts to equalize the charges.

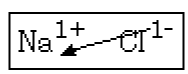
Suppose you must write the formula for sodium chloride. I'm sure you know the answer (NaCl), but let's pretend you don't.
Write down the Na^{+} and Cl^{-} right next to each other, as in this image:

Na^{1+} Cl^{1-}

Move the positive charge (dropping the sign) to the subscript position of the anion:



Move the negative charge (dropping the sign) to the subscript position of the cation:



The result of all this moving is:

Na_1Cl_1

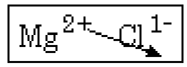
Since subscripts of one are not written, but understood to be present, the final answer is:

$NaCl$

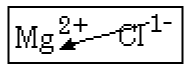
Write the formula for magnesium chloride.
Write down the Mg^{2+} and Cl^{-} right next to each other, as in this image:

$Mg^{2+} \quad Cl^{1-}$

Move the positive charge (dropping the sign) to the subscript position of the anion:



Move the negative charge (dropping the sign) to the subscript position of the cation:



The result of all this moving is:

Mg_1Cl_2

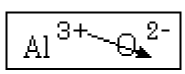
Since subscripts of one are not written, but understood to be present, the final answer is:

$MgCl_2$

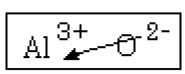
Write the formula for aluminum oxide.
Write down the Al^{3+} and O^{2-} right next to each other, as in this image:

$Al^{3+} \quad O^{2-}$

Move the positive charge (dropping the sign) to the subscript position of the anion:



Move the negative charge (dropping the sign) to the subscript position of the cation:



The result of all this moving is:

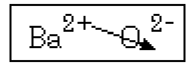
Al_2O_3

Notice that there is no fifth image in this problem. The Al_2O_3 is at a minimum set of subscripts, so no reducing is necessary. Not so in this next example.

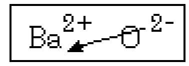
Write the formula for barium oxide.
Write down the Ba^{2+} and O^{2-} right next to each other, as in this image:

$Ba^{2+} \quad O^{2-}$

Move the positive charge (dropping the sign) to the subscript position of the anion:



Move the negative charge (dropping the sign) to the subscript position of the cation:



The result of all this moving is: Ba_2O_2

Since both subscripts have a common factor of two, we are not at a minimum set of subscripts. After reducing, the final answer is:

BaO

The Nomenclature of Hydrates

Hydrates are substances that include water into their formula.
The water is not actually part of the chemical substance and this is reflected in the way the formula is written.
Here is the example: $CuSO_4 \cdot 5\ H_2O$
This formula means that for every one $CuSO_4$ in the piece of this substance you are holding, there are also five water molecules. No, the substance is not wet, it appears dry. There are some hydrates that have a wet appearance, but most appear perfectly dry to the eye and to the touch.
The dot IS NOT a multiplication sign. Remember, this is chemistry, not math.
Here is the name: copper (II) sulfate pentahydrate. Notice penta meaning five and hydrate meaning water. You would use this name both when writing the name or speaking it.
That means that when you hear "pentahydrate," you have to know to write the dot and then the 5 H_2O.

There are Certain Formulas You Never Reduce

The most common ones are with mercury(I), which is Hg_2^{2+}.
It is **NEVER** Hg^+ by itself. It **ALWAYS** comes as a pair. There are reasons for this behavior, but that is beyond the scope of this work.

Example #1: mercury(I) nitrate

The formula for this compound is $Hg_2(NO_3)_2$. Once again, it is not reduced. Why?

In nature, mercury(I) comes in a set of two atoms, NOT just one.

The corresponding mercury(II) formula for the two examples would be $HgCl_2$ and $Hg(NO_3)_2$.

The second major category is peroxide, which is O_2^{2-}.

Example #2: hydrogen peroxide

The formula is H_2O_2 and it is not reduced to HO. Why? Same reason as above, peroxide travels as a group of two oxygen atoms, not one.

Example #3: sodium peroxide

The formula is Na_2O_2.

Chemistry I: Symbols and Charges for Monatomic Ions

Fixed Charge			
Symbol	**Name**	**Symbol**	**Name**
H^{+1}	hydrogen ion	H^{-1}	hydride
Li^{+1}	lithium ion	F^{-1}	fluoride
Na^{+1}	sodium ion	Cl^{-1}	chloride
K^{+1}	potassium ion	Br^{-1}	bromide
Rb^{+1}	rubidium ion	I^{-1}	iodide
Cs^{+1}	cesium ion	O^{-2}	oxide
Be^{+2}	beryllium ion	S^{-2}	sulfide
Mg^{+2}	magnesium ion	Se^{-2}	selenide
Ca^{+2}	calcium ion	Te^{-2}	telluride
Sr^{+2}	strontium ion	N^{-3}	nitride
Ba^{+2}	barium ion	P^{-3}	phosphide
Ra^{+2}	radium ion	As^{-3}	arsenide
Ag^{+1}	silver ion		
Zn^{+2}	zinc ion		
Al^{+3}	aluminum ion		

Note that the letters in an ion's name before the -ide ending is the stem.
For example, the stem for bromide is brom-. Also, just in case, the P for phosphide is a capital P.

Variable Charge					
	Systematic name	**Common**		**Systematic name**	**Common**
Symbol	**(Stock system)**	**name**	**Symbol**	**(Stock system)**	**name**
Cu^{+1}	copper (I)	cuprous	Hg_2^{+2}	mercury (I)	mercurous
Cu^{+2}	copper (II)	cupric	Hg^{+2}	mercury (II)	mercuric
Fe^{+2}	iron (II)	ferrous	Pb^{+2}	lead (II)	plumbous
Fe^{+3}	iron (III)	ferric	Pb^{+4}	lead (IV)	plumbic
Sn^{+2}	tin (II)	stannous	Co^{+2}	cobalt (II)	cobaltous
Sn^{+4}	tin (IV)	stannic	Co^{+3}	cobalt (III)	cobaltic
Cr^{+2}	chromium (II)	chromous	Ni^{+2}	nickel (II)	nickelous
Cr^{+3}	chromium (III)	chromic	Ni^{+4}	nickel (IV)	nickelic
Mn^{+2}	manganese (II)	manganous	Au^{+1}	gold (I)	aurous
Mn^{+3}	manganese (III)	manganic	Au^{+3}	gold (III)	auric

Chemistry I: Symbols and Charges for Polyatomic Ions

Formula	Name	Formula	Name
NO_3^{-1}	nitrate	ClO_4^{-1}	perchlorate
NO_2^{-1}	nitrite	ClO_3^{-1}	chlorate
CrO_4^{-2}	chromate	ClO_2^{-1}	chlorite
$Cr_2O_7^{-2}$	dichromate	ClO^{-1}	hypochlorite
CN^{-1}	cyanide	IO_4^{-1}	periodate
MnO_4^{-1}	permanganate	IO_3^{-1}	iodate
OH^{-1}	hydroxide	IO^{-1}	hypoiodite
O_2^{-2}	peroxide	BrO_3^{-1}	bromate
NH_2^{-1}	amide	BrO^{-1}	hypobromite
CO_3^{-2}	carbonate	HCO_3^{-1}	hydrogen carbonate (bicarbonate)
SO_4^{-2}	sulfate	HSO_4^{-1}	hydrogen sulfate (bisulfate)
SO_3^{-2}	sulfite	HSO_3^{-1}	hydrogen sulfite (bisulfite)
$C_2O_4^{-2}$	oxalate	$HC_2O_4^{-1}$	hydrogen oxalate (binoxalate)
PO_4^{-3}	phosphate	HPO_4^{-2}	hydrogen phosphate
PO_3^{-3}	phosphite	$H_2PO_4^{-1}$	dihydrogen phosphate
$S_2O_3^{-2}$	thiosulfate	HS^{-1}	hydrogen sulfide
AsO_4^{-3}	arsenate	BO_3^{-3}	borate
SeO_4^{-2}	selenate	$B_4O_7^{-2}$	tetraborate
SiO_3^{-2}	silicate	SiF_6^{-2}	hexafluorosilicate
$C_4H_4O_6^{-2}$	tartrate		
$C_2H_3O_2^{-1}$	acetate (an alternate way to write acetate is CH_3COO^-)		
NH_4^{+1}	ammonium		